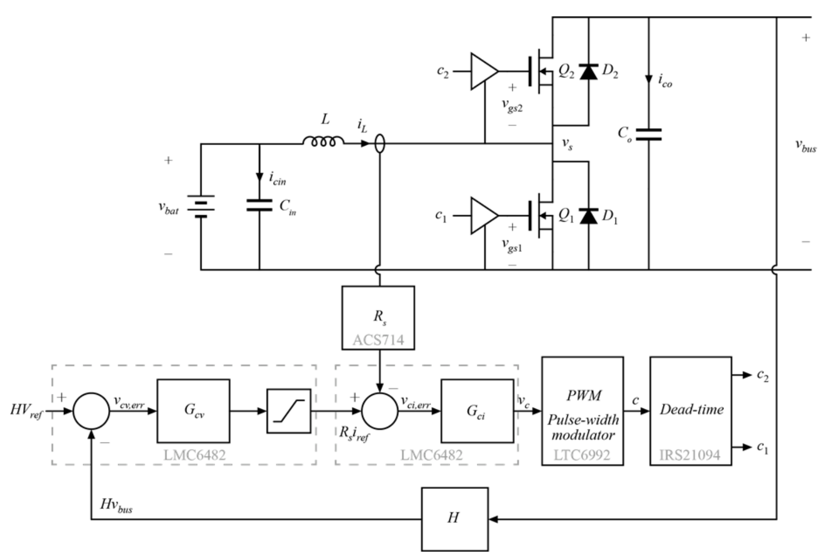
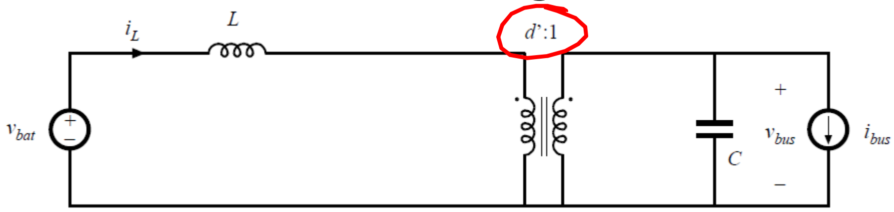
Boost Controller Design

ECE 482 Lecture 7
February 3, 2014

Controller Implementation



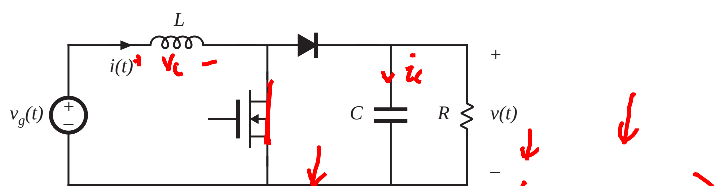
Nonlinear, Averaged Circuit



$$L\frac{d\langle i_L\rangle}{dt} = \langle v_{bat}\rangle - (1-d)\langle v_{bus}\rangle$$

$$C\frac{d\langle v_{bus}\rangle}{dt} = (1-d)\langle i_L\rangle - \langle i_{bus}\rangle$$

Nonlinear, Large-Signal Equations



$$\langle v_L\rangle = L\frac{d\langle i_L\rangle}{dt} = d(t)\langle v_g(t)\rangle + d'(t)\left(\langle v_g(t)\rangle - \langle v(t)\rangle\right)$$

$$\langle i_c\rangle = C\frac{d\langle v(t)\rangle}{dt} = -\frac{\langle v\rangle}{R}d(t) + d'(t)\left(\langle i_L(t)\rangle - \frac{\langle v(t)\rangle}{R}\right)$$

DC

DC only

$$0 = V_g - D'V$$

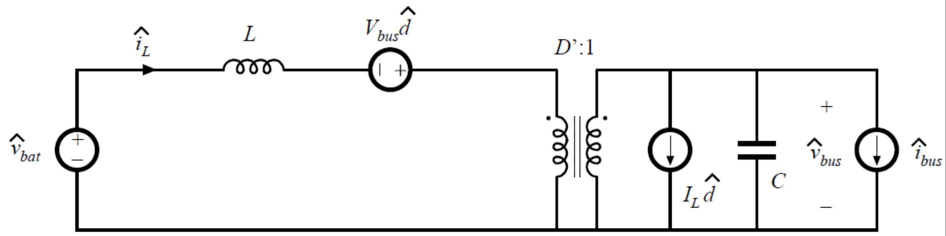
$$0 = D'I_L - \frac{V}{R}$$

Averaged AC

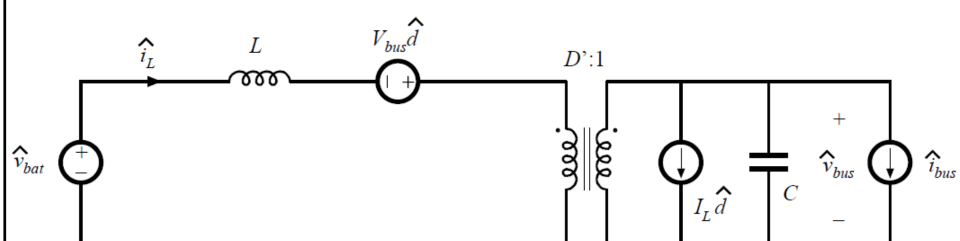
$$L\frac{d\hat{i}_L}{dt} = \hat{v}_g - D'\hat{v} + V\hat{d}$$

$$C\frac{d\hat{v}}{dt} = \frac{-\hat{v}}{R} + D'\hat{i}_L - I_L\hat{d}$$

Small-Singal AC Averaged Equic. Circuit Model



Open-Loop Control-to-Current TF



Find $G_{id}(s) = \left. \frac{\hat{i}_L}{\hat{d}} \right|_{\hat{v}_{bat}=0,\, \hat{i}_{bus}=0}$

Open-Loop Control-to-Current TF

Open-Loop Control-to-Current TF

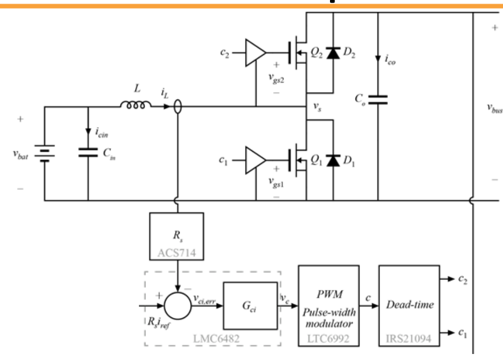
$$G_{id}(s) = \left.\frac{\hat{i}_L}{\hat{d}}\right|_{\hat{v}_{bat}=0,\,\hat{i}_{bus}=0} = G_{ido}\frac{1+\dfrac{s}{\omega_{zi}}}{1+\dfrac{s^2}{\omega_o^2}}$$

$$G_{ido} = \frac{I_L}{D'} = \frac{I_{bus}}{(D')^2}$$

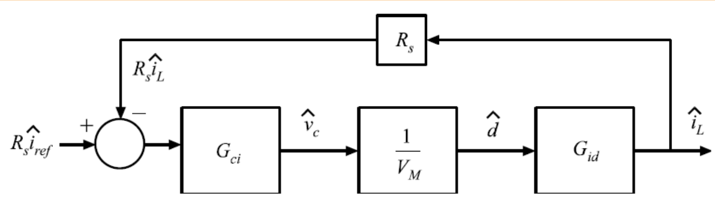
$$f_{zi} = \frac{1}{2\pi}\frac{1}{C}\frac{I_{bus}}{V_{bus}}$$

$$f_o = \frac{1}{2\pi}\frac{D'}{\sqrt{LC}}$$

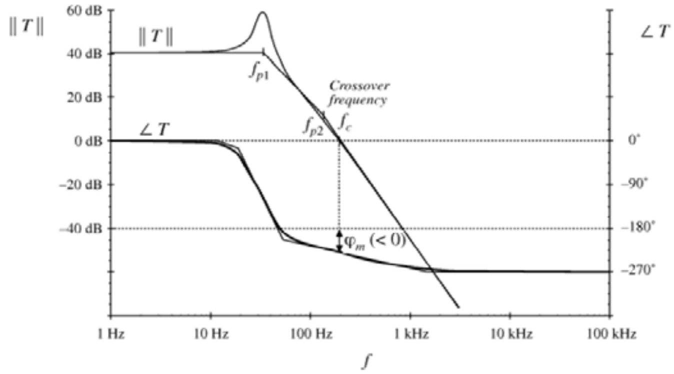
Current Control Loop



Current Loop Gain

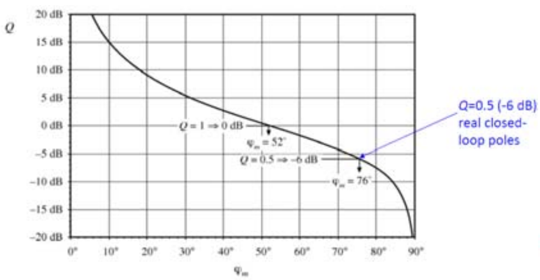


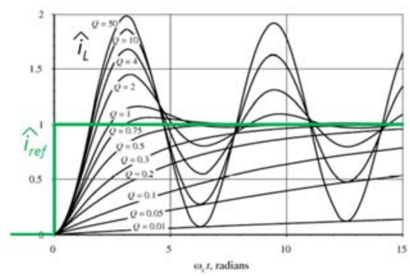
Loop Gain & Stability



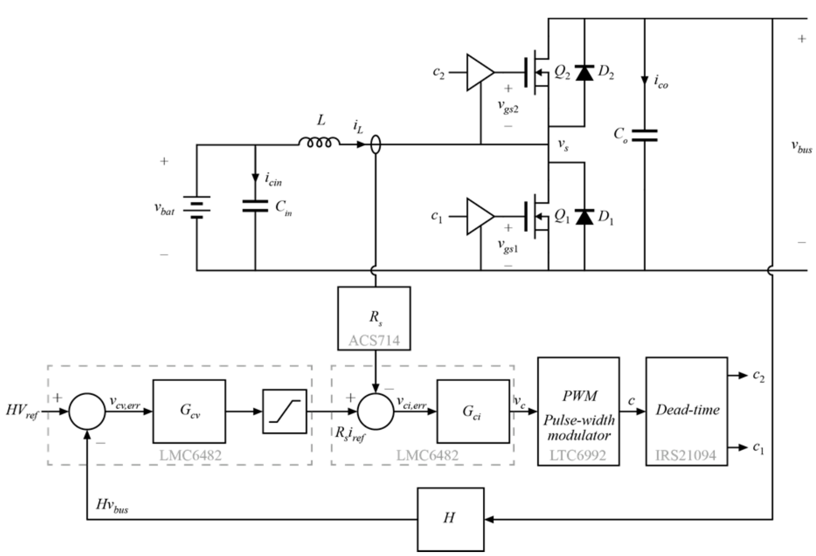
Phase Margin Test

Closed-Loop Response

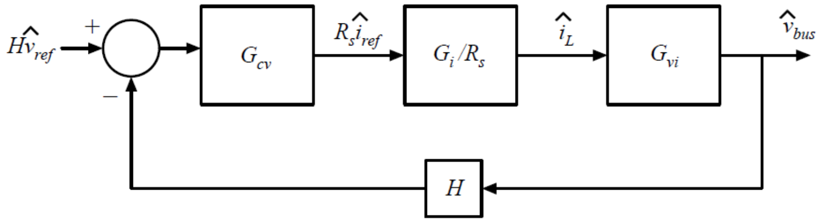




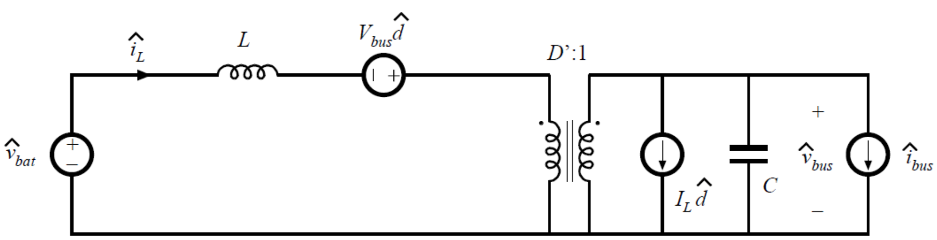
Voltage Loop



Voltage Loop Gain



Solving G_{vi}



$$G_{vi} = \left.\frac{\hat{v}_{bus}}{\hat{i}_L}\right|_{\hat{v}_{bat}=0,\, \hat{i}_{bus}=0}$$

Solving G_{vi}

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$$G_{vi} = \left.\frac{\hat{v}_{bus}}{\hat{i}_L}\right|_{\hat{v}_{bat}=0,\hat{i}_{bus}=0} = G_{vio}\frac{1-\frac{s}{\omega_z}}{1+\frac{s}{\omega_{zi}}}$$

$$G_{vio} = D'\frac{V_{bus}}{I_{bus}}$$

$$f_z = \frac{1}{2\pi}\frac{D'^2}{L}\frac{V_{bus}}{I_{bus}}$$

$$f_{zi} = \frac{1}{2\pi}\frac{1}{C}\frac{I_{bus}}{V_{bus}}$$